CHAPTER 13.

Emerald Ash Borer Infestation in Arkansas: Extent, Severity, and Progression

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INTRODUCTION

The invasive emerald ash borer (*Agrilus planipennis*; EAB) is currently present in five Canadian provinces and 35 States, including Arkansas, and has caused mortality of millions of ash (*Fraxinus* spp.) trees across the continent (Herms and McCullough 2014). The regulatory response following the initial 2002 EAB discovery took the form of large-scale detection surveys and establishment of quarantines to slow or prevent human-aided spread (BenDor and others 2006). Imposed quarantines restricted the movement of ash nursery stock and products, including firewood, from known infested areas. In Arkansas, a quarantine was implemented in September 2014 covering 25 counties, including six with confirmed EAB infestation sites. This quarantine was expanded in October 2016 to include eight additional counties, following confirmations in Randolph County and additional counties within the original quarantine area, and was further expanded to a statewide quarantine in March 2018. Detection surveys were usually not followed by delimiting surveys to establish infestation extent, estimate EAB population density, and provide baseline data for monitoring.

Quarantine and management strategies rely on understanding the current extent and severity of the infestation. Satellite colony establishment complicates making management decisions (Muirhead and others 2006) and, based on distances from known infested locations, may highlight quarantine effectiveness and relative contribution of human transport. More realistic parameterization of local and regional EAB spread models requires empirical data on realized spread (Siegert and others 2015). Moreover, information on the current infestation extent and severity would provide the basis for risk assessments and prioritization of treatment areas. The objectives of this study are to (1) document the extent, severity, and progression of EAB infestation in Arkansas; and (2) reconstruct EAB-induced ash tree mortality patterns as a surrogate for realized spread and infestation progression.

METHODS

The study area encompassed 17 southern Arkansas counties in which EAB was confirmed as of December 2017. The area is within the South Central Plains and Ouachita Mountains ecoregions (Woods and others 2004). Ash trees are sparse, representing 1 percent of gross live tree total bole volume within each of the two ecoregions, and are mainly distributed along major streams and rivers. The most pronounced ash distribution within the study area is found along the Little Missouri River and the Ouachita River in Clark and Ouachita Counties, respectively (fig. 13.1A).

Adult catches from EAB detection efforts since 2014 were compiled into a geodatabase. Data sources included original trapping, which was used to confirm EAB presence in a county as part of EAB national surveys, and any additional detection traps that were deployed within a county after confirmation. Detection traps (purple panel traps with [Z]-3-hexenol lures

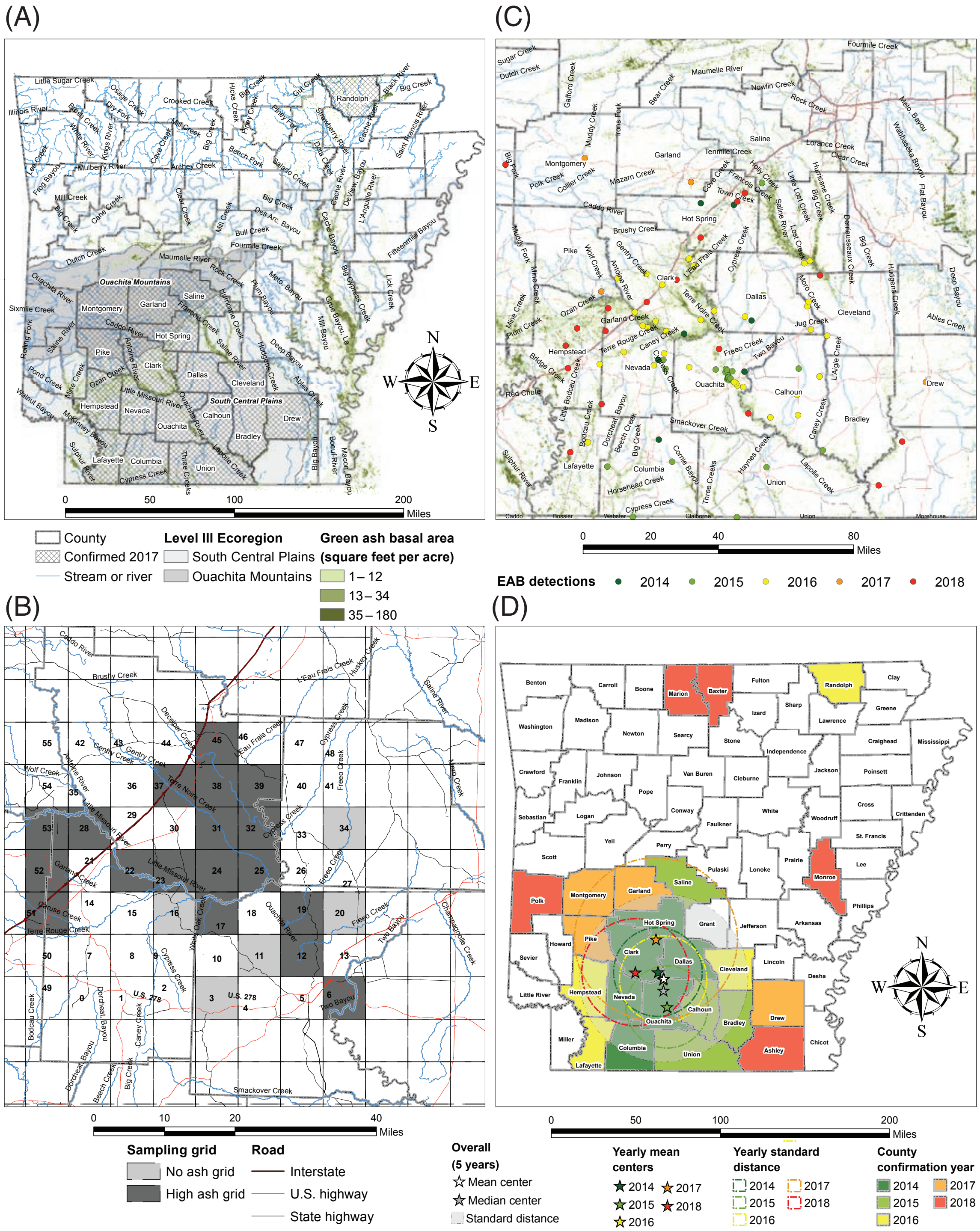

Figure 13.1—(A) Green ash basal area distribution along major streams and rivers within the two Arkansas ecoregions that encompass the 17 counties of the study area; (B) the 6- x 6-mile grid used for trapping of emerald ash borer (EAB) and reconstruction of EAB-induced ash tree mortality patterns; (C) EAB detections (positive adult catches), over a 5-year period from 2014 through 2018; (D) EAB county-level yearly confirmation with yearly and 5-year spatial summary statistics (mean, median, and standard distance circle of one standard deviation) of positive detections. Ecoregion level III boundaries (Woods and others 2004) are included for reference. Green ash distribution data derived from Individual Species Parameter Maps by the U.S. Department of Agriculture Forest Service, Forest Health Protection (FHP), Forest Health Assessment and Applied Sciences Team (FHAAST). (Data sources: FHP, FHAAST, and Arkansas GIS Office)

placed in the lower crowns of ash trees) were deployed within confirmed counties using a 6- x 6-mile grid encompassing the 17-county study area (fig. 13.1B), following the U.S. Department of Agriculture Animal and Plant Health Inspection Service (APHIS) EAB national survey guidelines (USDA APHIS 2015). Species identity of captured EAB adults in detection traps was confirmed under the microscope as outlined in Parsons (2008). Using the compiled geodatabase for EAB adult catches, infestations were mapped for the 17 counties over a 5-year period from 2014 to 2018 (fig. 13.1C).

To reconstruct EAB-induced ash mortality patterns, as a surrogate for realized spread and progression, the year of death at an annual resolution was determined for standing dead ash trees (i.e., snags). Radial increment cores were collected from declining, dead, and live trees across an area encompassing the majority of four counties with an initial confirmation in 2014, approximately 2,000 square miles (fig. 13.1B). The four counties (Clark, Dallas, Ouachita, and Nevada) represented an area with the earliest infestation date in Arkansas and highest abundance of ash. Systematic ash tree surveys were conducted in March and April of 2019 to locate and georeference EAB-symptomatic trees: trees with D-shaped exit holes, epicormic branching, woodpecker feeding, bark splits, and general canopy decline. Field visits utilized the 6- x 6-mile grid previously used for detection traps and included a total of 56 grid cells (fig. 13.1B). Due to higher abundance of ash trees along rivers and waterways, 18 grid cells covering the Little Missouri River, Ouachita River, Two Bayou, Freeo Creek, Terre Noire Creek, Deceiper Creek, Terre Rouge Creek, and Antoine River were sampled with higher intensity with an average of five ash trees sampled per grid cell (fig. 13.1B). No ash trees were found within five grid cells. Three ash trees per grid cell, on average, were randomly selected for sampling from the remaining 33 grid cells. Ash selection focused on dead and dying trees but included a minor component of asymptomatic live and symptomatic declining trees to ensure feasibility of crossdating ash snag cores. A total of 179 ash trees were sampled, 77 percent of which were snags.

Within each grid cell, snags were defined as standing dead ash trees with no visible buds or leaves but exhibiting symptoms of EAB infestation. Ash trees were classified into five decline classes ranging from 1 to 5, with a rank of 1 being healthy and 5 being standing dead (Knight and others 2012, Smith 2006). Trees with decline classes 1 through 4 were used as reference in crossdating and determination of year of death. To capture EAB-induced mortality and not that of other causal factors, such as density-dependent mortality, trees were selected if they were currently or previously in the canopy as judged from size and characteristics of trees, and gaps when tops were broken. Consequently, trees along edges of forest stands and trees with dominant and codominant crown positions were favored in sample selection. Sampled locations represented urban, rural residential, and forested or wooded areas. Georeferenced asymptomatic and declining ash trees' and snags' diameter at breast height (d.b.h.), total height, crown position class (dominant, codominant, intermediate, or suppressed), and decline status were recorded. Snag decay status was also recorded using a three-level categorical variable as: 1 = recently dead tree with fine branches present and intact bark and top; 2 = declining snag with most fine branches missing but large limbs present or broken, broken top, and loose or sloughing bark; 3 = decayed snag with no coarse branches and sloughed off bark.

Two radial increments were collected at breast height at right angles for each sampled tree. Tree cores were air dried, glued, sanded, and processed following standard methodology (Stokes and Smiley 1968). Tree cores were scanned using an Epson® Expression 11000XL scanner and Epson® scanner software. The width of each tree ring was measured to the nearest 0.000039 inches (0.001 mm) using WinDendro™ software. Cores were visually, graphically, and statistically crossdated by matching patterns in tree ring widths among samples from the same tree and then trees within a grid cell. COFECHA software was used to verify measurement quality and perform statistical crossdating (Grissino-Mayer 2001, Holmes 1983). Master chronologies developed using COFECHA from asymptomatic and declining ash trees with calendar year assigned to each annual growth ring were compared to tree ring widths from dead trees. Year of death was assigned to the outermost ring based on marker years and pattern matching with the master chronology, and quality of dating was checked using the undated series option in COFECHA (Bataineh and Daniels 2014, Daniels and others 1997, Siegert and others 2014).

Year of death estimates for each tree location were mapped and used in spatial overlays with adult trap catches. Ash distribution maps from the Individual Tree Species Parameter (ITSP) maps (Ellenwood and others 2015) were also used in the overlay analysis to examine effect of host abundance and distribution on EAB realized spread. The ITSP green ash (*Fraxinus pennsylvanica*) raster basal area estimates were clipped to the study area and then reclassified into three basal area-based abundance classes. Other available spatial datasets including roads, public land boundaries, and number of camp and lodge structures (used for hunting, fishing, hiking, and other recreational purposes) were also used in overlays. Spatial statistics and point density estimates were calculated for year of tree death and trap catch layers using ArcGIS 10.7 tools.

RESULTS AND DISCUSSION

For the 5-year period, 2014 through 2018, 229 traps were deployed across the study area. Overall detection rate was 47 percent for the entire time period, with 107 positive catch traps and 122 traps with no catches. The EAB detections radiated outward from the original seven locations encompassed by the six counties confirmed in 2014 (figs. 13.1C and 13.1D). In some cases, EAB was detected 80 to 90 miles away from known infestations as was the case for detections in Monroe County, outside the study area. Similar to other areas nationwide, outlier populations continued to appear within the designated quarantine zone in Arkansas, and outreach campaigns did not seem effective in limiting infested material transport as was previously hypothesized (Siegert and others 2015). The median location for the point pattern created by adult trap catches for the 5-year period was centered at latitude 33.70833°N and longitude -92.893242°W, located along the Ouachita River between Old River Island to the north and Tulip Creek to the south (fig. 13.1D). The mean location (33.81212°N, -92.890096°W) was centered 7 miles due north of median near the corners of Dallas, Clark, and Ouachita Counties (fig. 13.1D). The mean and median locations represented the spatial centers of the detection pattern over the 5-year period with less influence of perimeter traps on the median than mean center. A standard distance of 50 miles, one standard deviation, radiating from the mean center contained 81 percent of positive trap catch locations over the 5-year period. For each trapping year, mean centers and standard distances reflected the outward spread and dispersion of EAB detections with 1.8- and 1.2-fold increases in standard distance for 2017 and 2018, respectively (fig. 13.1D). Increases in standard distance were more drastic when detection records outside the study area were included, with 1.5-, 2-, and 3-fold increases in standard distance for 2016, 2017, and 2018, respectively.

A total of 179 ash trees were georeferenced and measured. Ash snags made up 77 percent of the sample (138 trees) with an additional 11 percent (19 trees) in severe decline. Mean ± SD (standard deviation) of d.b.h. and total height for all sampled trees were 9.4 ± 4.3 inches and 48.6 ± 19.1 feet, respectively. Ash trees, live and dead, were mainly of the dominant or codominant crown positions (82 percent), and the remaining were of intermediate or suppressed position (18 percent). Most ash snags were also dominant or codominant (82 percent). Based on branch, top, and bark conditions, most ash snags were recently dead (65 percent) or in a moderate decline stage (21 percent).

Trap detection of EAB appeared to lag behind EAB-induced ash tree mortality by at least 1 year (fig. 13.2). Earliest EAB-induced mortality occurred in 2013 with the majority (68 percent) dying within 2 years of the first State detection, indicating that ash trees may be dying within a shorter time frame compared to the 6-year period reported at the northern range (Knight and others 2012). Stand density was reported to influence ash mortality rates with more rapid mortality in stands, as those reported in this study, with low density (Knight and others 2012). Only a few trees along the Terre Noire and Terre Rouge Creeks in Clark and Nevada Counties, respectively, had died in 2013. Ash tree mortality had progressed along the Little Missouri River in 2014, spanning 20 to 30 miles in a counter flow direction, when the first State detections were reported. About half (55 percent) of 2014 ash snags were in Clark County, with 18, 14, 5, and 5 percent of 2014 snags in Nevada, Ouachita, Hempstead, and Dallas Counties, respectively. Nearest positive trap detections, in

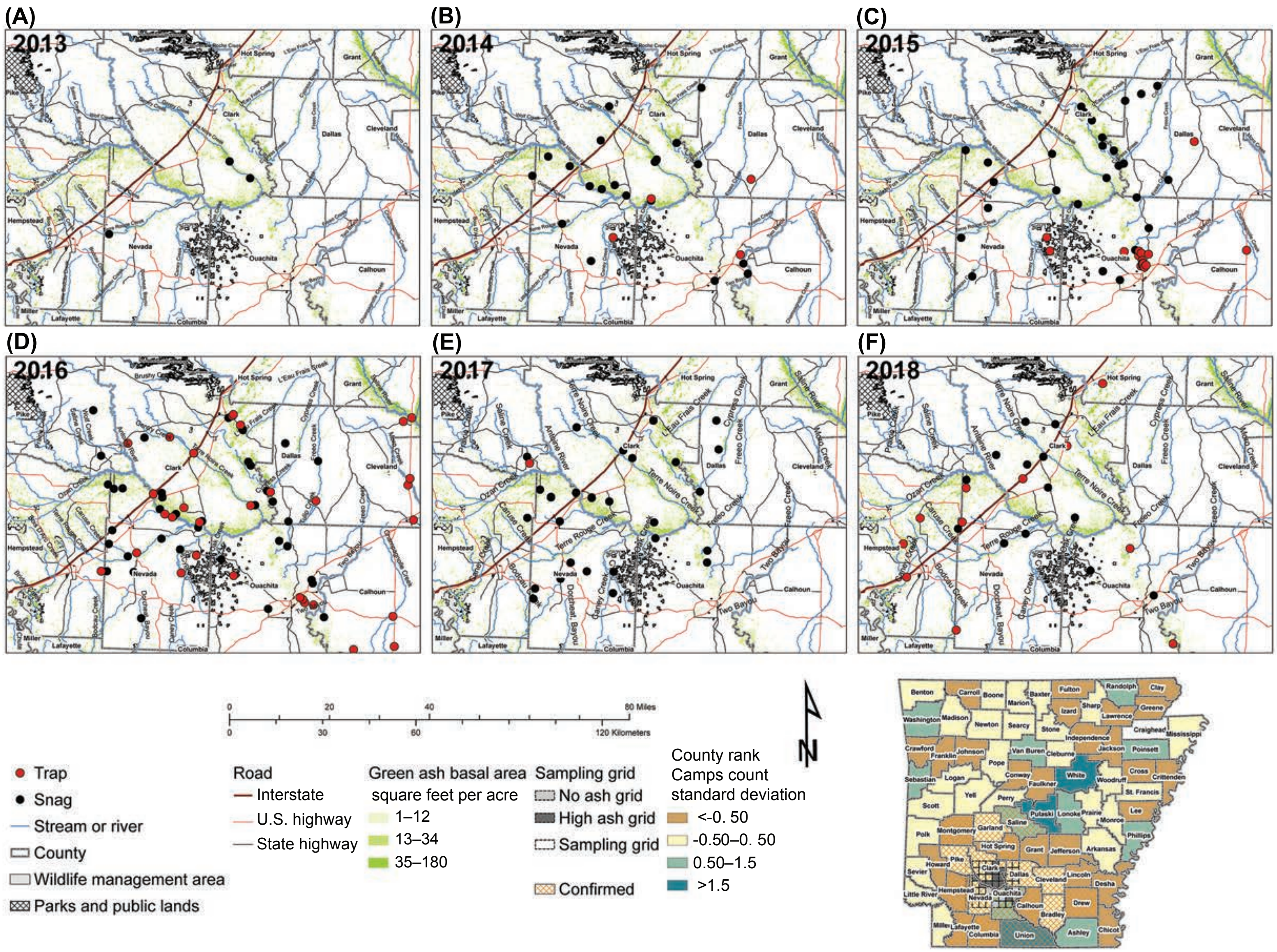

Figure 13.2—Annual progression in (A) 2013, (B) 2014, (C) 2015, (D) 2016, (E) 2017, and (F) 2018 of emerald ash borer-induced mortality in relation to annual positive trap detections, host abundance and distribution, and other cultural features such as roads, camps, and public lands within an area encompassing the majority of four Arkansas counties. Green ash distribution data derived from Individual Species Parameter Maps by the U.S. Department of Agriculture Forest Service, Forest Health Protection (FHP), Forest Health Assessment and Applied Sciences Team (FHAAST). (Data sources: FHP, FHAAST, and Arkansas GIS Office)

2014, were between 0.3 and 11 miles from an ash snag killed that year, but a distance of 6.5 to 15.6 miles separated these detections from an ash snag killed in 2013. Public lands in Clark and Nevada Counties included DeGray Lake Recreational Area and Poison Springs State Forest and Wildlife Management Area, respectively. Interstate 30 (I-30) traverses Clark County from northeast to southwest and passes through the upper northwest corner of Nevada County. Using density of camps and lodges as a surrogate for human movement of firewood, Clark and Nevada Counties had a relatively low number of camps and lodges, 19 and 13 respectively, compared to Ouachita County, which contained 104 camps and lodges (fig. 13.2). Ash snags in Pike and Hempstead Counties were dated at earliest to 2016 and 2014, respectively, whereas earliest positive trap catches were reported in 2017 and 2016, respectively (fig. 13.2).

The concentration of ash hosts along major streams and rivers within the study area appeared to facilitate both short-distance colonization and long-distance dispersal by EAB (fig. 13.2). Aggregates of ash trees with relatively sequential death dates from 2013 through 2017 or 2018 were evident along the Little Missouri River, Terre Noire Creek, Terre Rouge Creek, and Deceiper Creek (fig. 13.2). Simultaneously, latest ash snag death dates radiated perpendicularly away from drainage channels as host abundance declined. Thus, abundance of hosts along drainage channels appeared to facilitate short-distance colonization, whereas scarcity of hosts away from drainage channels seemed to facilitate long-distance dispersal and therefore support the establishment of outlier populations. The effect of host proximity in this spatiotemporal pattern is consistent with reports of substantially increased colonization likelihood with abundant ash within 650 feet of infestation centers (Siegert and others 2010). The onset of EAB infestation appeared to be concentrated in Clark and Nevada Counties, which is not surprising given the high ash abundance, proximity to public land and recreational areas, and the fact that a major road artery, I-30, traverses both counties.

Point density estimates of adult counts per unit area showed high EAB density along I-30 and along the Little Missouri and Ouachita Rivers (fig. 13.3A). Highest density of one adult caught per square mile was recorded at the northwestern border of Cleveland County along the Saline River. This highlighted the high risk of potential mortality along this drainage. The relatively high ash abundance along the Saline River coupled with lack of field observations of ash mortality indicate that EAB spread may continue northward and southward along the Saline River, threatening valuable ash trees within these bottomland hardwood forests. Therefore, areas along the Saline River should be of high priority in scheduling salvage and sanitation harvests. Other high-density locations included: an area near Camden between the Ouachita River and Two Bayou; and an area 13 miles north of Hope, near Ozan (fig. 13.3A). Ash snag point density estimates per unit area showed clustering of dead trees along the Little Missouri River, Deceiper Creek, Terre Noire Creek, Ouachita River, and

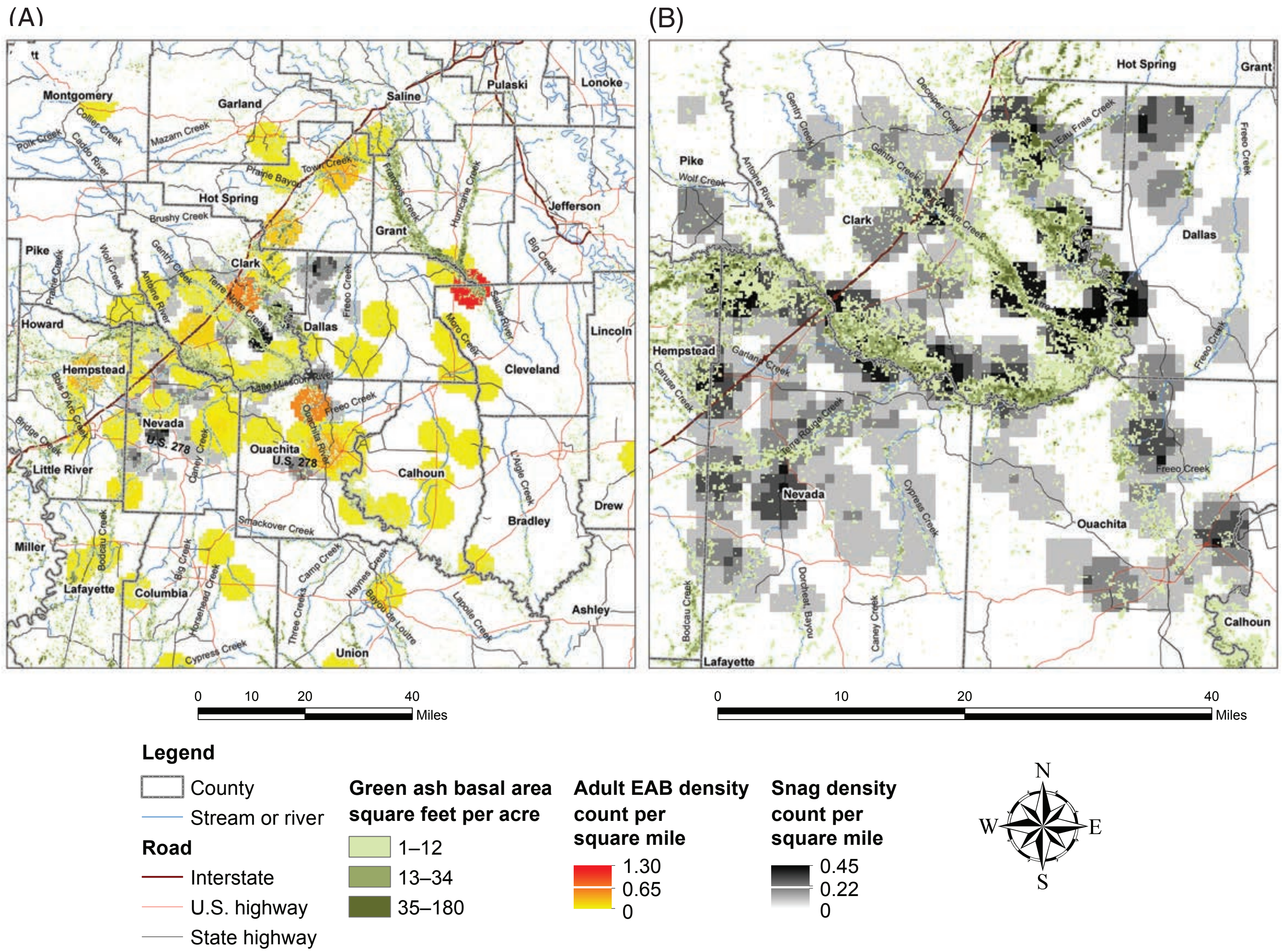

Figure 13.3—(A) Density of emerald ash borer (EAB) detections and (B) EAB-killed ash snags, counts per square mile, over a 5-year period from 2014 through 2018. Green ash distribution data derived from Individual Species Parameter Maps by the Forest Service, Forest Health Protection, Forest Health Assessment and Applied Sciences Team. (Data sources: Forest Health Protection, FHAAST, and Arkansas GIS Office)

along the I-30 corridor (fig. 13.3B). Highest density of one snag per 2 square miles was recorded at the confluence of Terre Noire and Deceiper Creeks. Ash snag and EAB population densities provided somewhat similar accounts of the severity of the current infestation (fig. 13.3). This concordance highlights the feasibility of using EAB population density as an indirect measure of potential ash mortality at larger landscape scales. It appears, however, that in areas of low host abundance, trap detection is less effective in highlighting infestation severity, which may be circumvented by placing traps along waterways where hosts are abundant.

CONCLUSIONS

To inform EAB regulatory and management response, the extent, severity, and progression of the Arkansas infestation were documented and mapped. Reconstruction of ash tree mortality coupled with spatially explicit trap detection records provided the basis for examination of realized spread and progression of the EAB infestation. Human transport of infested material appeared to continue to play a role in expanding the spread, but the spatial arrangement of the ash host in linear fashions along waterways also appeared to play a role in spread expansion by facilitating both short-distance colonization and long-distance dispersal. Outward progression was characteristic of satellite population establishment as opposed to expansion of original infestations. Human transport of infested material, which is the focus of quarantine implementation, did not seem to be hindered, and EAB satellite populations were detected 20 to 30 miles away from known infested areas. Trap detections lagged behind the onset of ash tree mortality by at least 1 year, highlighting the difficulty of early detection of invasive borers like EAB. Trap detections also appeared to be less effective in highlighting infestation severity in areas of low host abundance, which may be improved by placing traps along waterways where the host is more abundant. A multitude of factors including host abundance, road networks, and proximity to public land and recreational areas seem to have contributed to the highest infestation severity occurring in Clark County. The onset of EAB infestations appeared to be concentrated in Clark and Nevada Counties. As EAB spread continues, bottomland hardwood forests along the Saline River have high risk of potential EAB-induced ash tree mortality.

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